

as great from August 28 to 29 (Chicago-Cape Hatteras) and a correspondingly rapid passage to the English coast in only 4 days.

Since weather reports and especially storm reports are now transmitted to ships by wireless my chart can serve in finding the approximate meeting place of ship and storm, especially since 10 m. p. s. is also the speed of many steamships.

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# THE PHYSICAL AND GEOLOGICAL TRACES OF THE CYCLONE BELT ACROSS 'NORTH AMERICA'

By MARSDEN MANSON

[802 Hobart Building, San Francisco, Calif., December 5, 1924]

Whenever certain portions of the earth for long periods of time have been subjected to meteorological conditions differing from those imposed upon other areas, these different conditions set their marks. These marks, when correctly interpreted, yield lessons of wide import.

It is the object of this essay to show that the path of cyclonic activity of greatest frequency across the narrow continent of North America, from the wide Pacific to the Atlantic, has been subjected to maximum cyclonic activity along this belt, and that this action has persisted well back into geologic history. As the basis of this study, the tracks of Lows as charted by the United States Weather Bureau and published in the MONTHLY WEATHER REVIEW are used.

These tracks were studied for two periods, the first, for the 12 months beginning December 1, 1891, and ending November 30, 1892; the second, for the 12 months beginning December 1, 1921, and ending November 30, 1922.

In these studies each LOW which crossed the continent during these years was traced in distinguishing colors and lines from the UNITED STATES MONTHLY WEATHER REVIEW charts by seasons and by months.<sup>1</sup> From these the limits of the tracks of Lows is outlined upon the accompanying chart; also the summit of the drainage into the Arctic Ocean, Hudson Bay, etc., and into the Gulfs of Mexico and California, etc.

It will be observed that the greater number of these storms move between quite well defined limits, although there are very wide divergent courses taken by some. The most important divergence is that which occurs seasonally on the Pacific coast as the sun moves to its solstitial positions, the summer course being more northerly than that of winter, and during the summer practically no rain falls near the coast south of parallel 42° N. These changes in the paths of Lows approaching and crossing the coast line, thence into the interior of the continent, establish the wet and dry seasons of California and adjacent territory. Departures from this general winter course give abnormal seasonal precipitation in this State and a reversed abnormality north of this belt.

<sup>1</sup> The original studies of this subject were published in the *Transactions of the Technical Society of the Pacific Coast*, July, 1891, under the title, "Physical and Geological Traces of Permanent Cyclone Belts."

This subjects was extended to include the movement of cyclones across the Atlantic Ocean and the continent of Euro-Asia. The present paper is revised and rewritten from the above, and is restricted as indicated in the title.

In April, 1893, the author presented a paper to the Science Association of the University of California, entitled, "The Importance of North Pacific Weather Stations."

The colored maps of the earlier period of cyclone tracks across the continent issued in this paper are utilized herein. See also *Bulletin A*, U. S. Weather Bureau, H. H. C. Dunwoody, Washington, D. C., 1893. *Atlas of Meteorology*, Plate 28, Bartholomew, Edinburgh, Geographical Institute, 1899.

<sup>2</sup> In the tracks of cyclonic areas during the second period, or 30 years later than the first, a larger number of Lows appear to have developed over the arid and semiarid regions of New Mexico, Arizona, California, and Mexico than in the former period. This is probably due to the establishment of a larger number of observing stations and more intensive studies of the data.

It is probable that the cyclones originating over this area are developments of the modern era of solar climatic control, which, in the views of the writer, did not prevail during geological climates. This subject can not be treated in this essay, but can be found in *The Evolution of Climates*, Manson, 1922.

As the vertical sun approaches the equinoctial position over the Equator, some of the Lows follow the winter and others the summer track, thus causing the spring and autumn rains of California to be lighter than those of winter, and fixing these seasons as wet or dry according to whether the greater number or intensity of Lows follow the winter or summer course.

*Counteracting pressures of anticyclonic areas.*—Opposed to the lessening of pressure attending the passage of a LOW stands the increased pressure due to the passage of a HIGH. The surface of the earth, in isostatic equilibrium, is acted upon by these decreases and increases of pressure.<sup>3</sup> Doubtless the one should in a measure tend to counterbalance the other, if imposed upon the same areas and of equal force. But the Weather Bureau reports above referred to show that the paths of HIGHS are more widely different from those of Lows. The HIGHS are not accompanied by the denuding effects of rain and snow, as are the Lows. Hence the latter have unbalanced effects in their favor, and these must have their cumulative results as herein pointed out.

Now, if this great path of north temperate Lows shall have remained fixed during the Modern Era, and indefinitely into the geologic past, distinctive physical and geologic traces must have resulted from this concentration of denuding activities.

In order to present the ultimate effects which the continued occurrence of a difference in barometric pressure is capable of producing, we must realize that over each square foot subjected to 1 inch less barometric pressure than another a relief of 70.5 pounds obtains. Upon a square mile this amounts to 877,000 tons; a difference of 1 inch is not unusual; indeed, this is not far from the average, and this lessening of pressure acts over areas several hundred miles in diameter. This action, with the accompanying denuding agencies, is repeated every few days now, and could not have been inoperative at any fixed period in geologic time, since one of its causes is the greater amount of solar energy absorbed by the air in the longer oblique path of solar radiation through it about latitude 50°.

This lessening of pressure is equivalent to a lifting force and may seem inconsiderable to the geologist accustomed to consider forces of vaster magnitude; but the great factor time being multiplied into the results gives them mass effects not at first realized. The results of the passage of a single cyclone are physically and geologically insignificant; those passing in a year might be recognized by careful measurements of sedimentations; those passing in several centuries could be so recorded that their results could be observed by successive generations; but when this factor time becomes lengthened into geologic units the effects become physically and geologically traceable.

*Physical traces.*—The parting of the waters draining into the Arctic Ocean and Hudson Bay, and into the Gulf of Mexico and the Atlantic Ocean, commences on the summit of the Rockies in about 49° N., thence eastwardly in a sinuous line to 75° E. longitude, thence northeastwardly to southwest Labrador in 57° N.

A section of the continent from the mouth of the Mississippi River to that of the Mackenzie crosses this divide near Winnipeg, and both of these great rivers rise on the summit of the great continental plateau.

<sup>3</sup> A convenient instrument for noting the approach and passage of areas of varying air pressures is the seismograph, and it is probable that properly placed seismographs would give warning of the approach of a LOW or of a HIGH prior to the barometer. The observations and researches of Mr. F. Napier Dennison, member of the American Meteorological Society, etc., are notable instances of original work in this field.

Profiles of the continent along the 50th, 35th, and 65th parallels show that the least differences in elevation occur along or near the 50th parallel; and the profiles along the 35th and 65th parallels cross the great valleys at much lower and the great divides at much higher elevations. Moreover, the peaks and passes near parallel 50° N. are lower by from one-half to a full mile than Mount St. Elias, 60½° N.; Mount McKinley, 63½° N.; Mount Wrangell, 61½° N.; all of which are still subject to severe glacial action. The peaks and passes to the south are also far higher, as Mount Shasta, 41½° N., and Mount Whitney, 36½° N. The path of maximum cyclonic activity lies practically along this great east and west watershed, along which maximum denuding activities are concentrated, and from which the denuded materials have been borne to the areas of sedimentation at the mouths of the great rivers. Thus slowly lightening the crustal load at the summit and loading the areas of sedimentation, and tending to cause the former to be an area of slow upheaval and the latter of slow depression.

continental glacier.<sup>5</sup> The geologic evidence that this course of cyclonic activity prevailed during the Ice Age is thus made probable. In the remote Huronian, very extensive glaciation occurred in the interior of Canada and as far south as 46° N. along this path of cyclonic activity. This glaciation was near the center of the continent and remote from the ameliorating influences of warm oceans. Glaciation did not extend from coast to coast, as during the Ice Age, when far colder oceans prevailed.

In the general distribution of the exposure of the rocks of various ages, it is worthy of note that in the continental section from the mouth of the Mississippi to that of the Mackenzie, the oldest rocks are at the heads of these rivers, and the greatest areas of their exposures lie along and adjacent to the zone of maximum cyclonic activity; that the modern rocks are in process of formation at the mouths of these rivers; and that the exposures of rocks of intermediate formations are between these extremes.

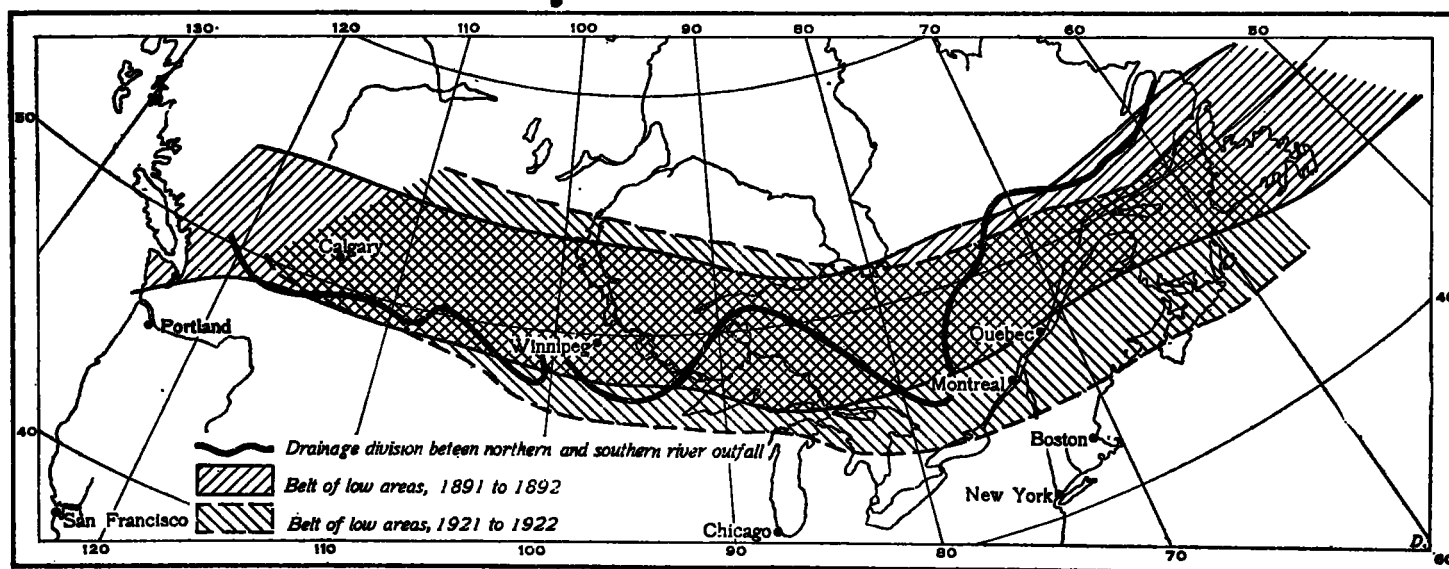


FIG. 1.—Belts of low barometric pressure during 1891-92 and 1921-22, and the line of drainage division between rivers of north and south outfall

*Geological traces*—The extension of this path into earlier eras.—The geological traces of this concentration of maximum denuding agencies are consequent upon and confirmatory of the evidences of the physical traces just reviewed. The flow of glacial ice and the distribution of till from this zone or path of Lows is very marked to the South and far less so to the North. In the Mississippi Valley it reaches 38° N. and in that of the Mackenzie 65° N. This greater flow to the South was manifestly caused by the successive partial melting off of the continental glacier during the warm interglacial epochs, and its final melting, all of which were due to exposure to solar energy, to which the southerly slope was most exposed. These meltings and the similarity of the groups of life, which during the warm interglacial epochs occupied the deglaciated areas to those of the Modern Era point to similar control.<sup>4</sup>

Glacial dispersion northerly was thus very much checked, and ice and the materials of till were manifestly drawn southward from the northerly slope of the great

There is no evidence available to the writer which would tend to show that this zone or path of maximum cyclonic activity has not prevailed during geologic time.

#### CONCLUSIONS

The concentration of cyclonic activities along the course indicated herein has produced three general results:

1. The denudation and upheaval of the crust to its maximum extent along this course and the establishment of the continental drainage line east and west.

<sup>4</sup> There still persists the view that polar regions were the great sources of glacial dispersion, from which "Arctic conditions swept down from their polar strongholds and invaded the Temperate Zones and even the Tropics." Joly, "The Age of the Earth," p. 32.

Huntington and Visher go into quite an argument to show that the presence of glacial conditions would divert the course of Lows more to the northward. "Climatic Changes," pp. 115 et seq.

But there does not appear to be sufficient evidence to support these views. The checking of marked glacial flow northward of the crest of the continental glacier tends to negative this last argument; and the presence of ferns, corals, figs, and magnolias, etc., in the Arctic regions during the Permian glaciation of the Tropics does not admit of the former interpretation.

<sup>5</sup> See *The Evolution of Climates*, Manson, 1922.

2. This concentration of denuding agencies has worn down the peaks and passes and the plateau regions along this course to the maximum extent, thus causing their slow and constant upheaval, and a corresponding depression of remote areas to which the sediments have been borne.

3. This denudation has also caused maximum exposures of the oldest formations along this path.

The traces of cyclonic activity are thus marked both physically and geologically across the continent.

### DETERMINING ATMOSPHERIC CONDITIONS OF COMFORT

628.85

By FRANK M. PHILLIPS, Ph. D.

[George Washington University, Washington, D. C., December 7, 1924]

Much is being written in the various scientific journals and books on optimum conditions of heat and humidity for human beings engaged in different activities. The

attempt, apparently, is to determine conditions of comfort. The question at stake is not so much what atmospheric conditions are most bracing, nor what give the body most resistance, nor what points on the thermometric and the barometric scales are conducive to health, but what conditions give the least discomfort, which may be one and the same thing as optimum conditions for health.

The New South Wales factory act<sup>1</sup> requires a mean dew point of 62° F., and allows a variation of only 5° either way.

The writer has devised the accompanying chart showing several scales for atmospheric conditions. The horizontal scale is for dry-bulb readings, the vertical one for wet-bulb readings. The solid curves running diagonally across the chart give the relative humidity readings, and the dotted lines give the corresponding dew-point scale. The psychrometric readings can thus be converted into relative humidity and dew-point readings at a glance.

<sup>1</sup> Purdy, J. S.: Lighting and Ventilation of Factories. *The Journal of Industrial Hygiene*, March, 1922, pp. 349-358.

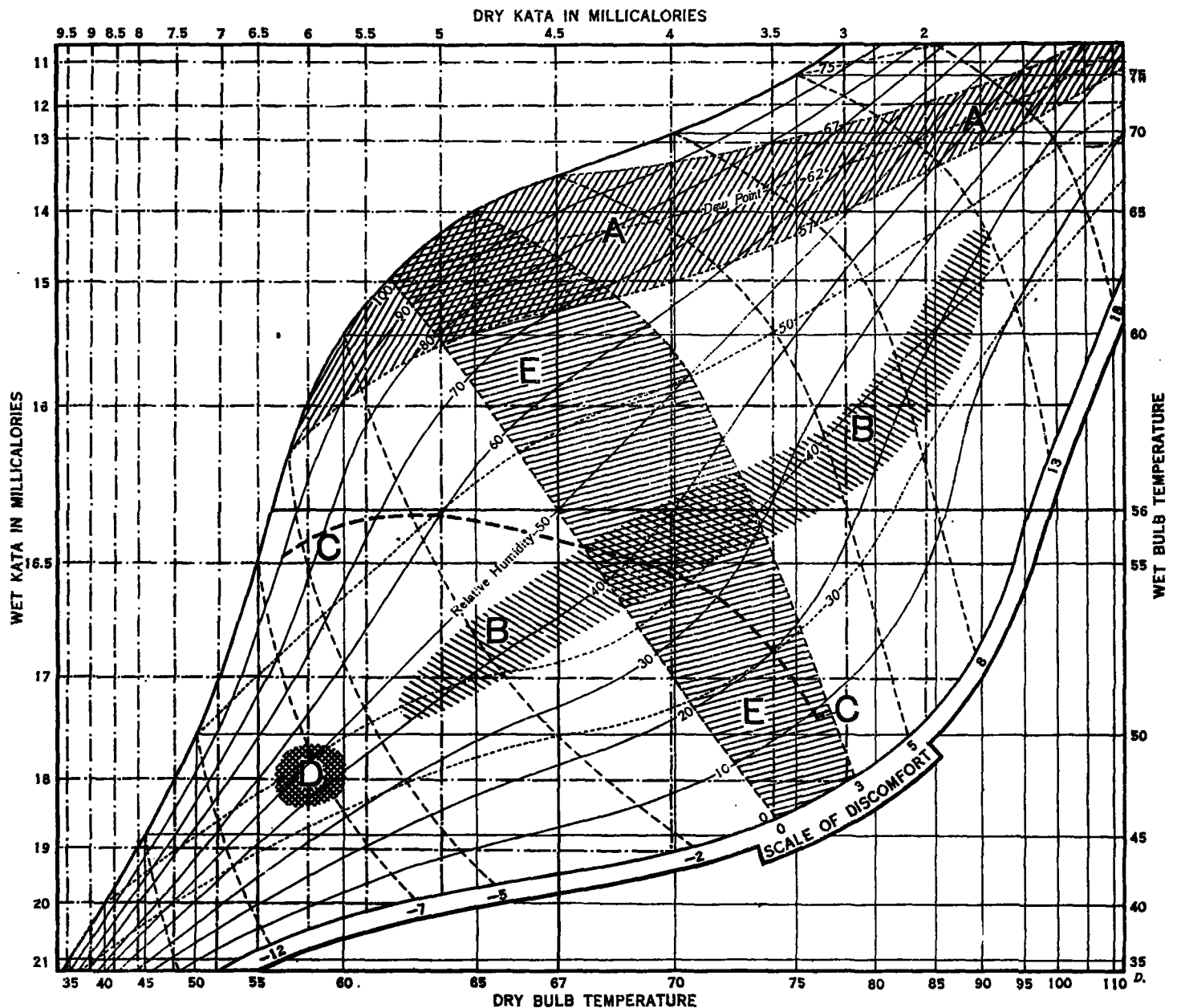


FIGURE 1.